

# ***The Human-AI Interaction of AI Translation in Cross-Cultural Classrooms Based on the Theory of Interactive Media Effect***

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**Abstract.** This study examines how Chinese international students engage with AI translation tools in English-medium instruction (EMI) classrooms, focusing on their impact on learning processes and cross-cultural understanding. Drawing on the Human-AI Interaction Theory of Interactive Media Effects (HAI-TIME), the research integrates the “cues route” (interface design, algorithmic attributes, prior experience, and cognitive heuristics) and the “action route” (interaction, agency, social exchange, and mutual augmentation) to analyze human-AI collaboration in academic contexts. Data were collected through semi-structured interviews with 23 students, the majority of whom were enrolled in EMI programs in the United States, the United Kingdom, Australia, and Hong Kong SAR. Thematic analysis points out that AI translation preserves comprehension, eases anxiety, and fosters student engagement, yet its limitations in cultural adaptation and pragmatic nuances often necessitate compensatory strategies like cross-platform comparison and iterative prompting. Findings highlight the reciprocal interaction of cues and actions. The study substantiates and extends the HAI-TIME framework's explanatory efficacy. Underlines the necessity of transparency and cultural adaptability in tool design, and suggests practical strategies for embedding AI translation in cross-cultural education, while warning against the potential hazards of overreliance. Underlines the necessity of transparency and cultural adaptability in tool design, and suggests practical strategies for embedding AI translation in cross-cultural education, while warning against the potential hazards of overreliance.

**Keywords:** AI Translation, Cross-Cultural Communication, Human-Machine Interaction, HAI-TIME Theory, Media Affordances.

## 1. Introduction

The rapid evolution of artificial intelligence has restructured the translation sector, thereby modifying the process of multilingual communication in educational contexts. The adoption of AI translation systems like ChatGPT, DeepL, and Youdao in English-taught classrooms is expanding, ensuring swift language support and cultural translation. Significance is notably attributed to this transformation for the growing number of Chinese international students, whose educational trajectory commonly necessitates the management of complex disciplinary discourses, specialized vocabularies, and culturally embedded expressions. Translation technologies' necessity in these contexts is propelled by the imperative to surmount linguistic obstacles and the challenge of executing effective cross-cultural dialogue. Translation technologies' necessity in these contexts is propelled by the imperative to surmount linguistic obstacles and the intricacy of executing effective cross-cultural dialogue.

The Human-AI Interaction Theory of Interactive Media Effects (HAIL-TIME) offers a meaningful framework for examining the influence of interface cues, algorithmic traits, and perceived capabilities on user engagement and cognitive processing in this transforming scenario. The theory emphasizes the reciprocal aspects of human-AI interaction, demonstrating how students' agency, trustworthiness, and adaptive strategies modify the quality of translation and the depth of intercultural understanding. The theory underscores the bidirectional dynamics of human-AI interaction, highlighting the influence of students' agency, reliability, and adaptive tactics on the quality of translation outputs and the profundity of intercultural comprehension.

Considering this backdrop, this study investigates the subsequent question: How does the interaction between human and AI translation in English-taught classrooms influence the learning of Chinese international students and their cross-cultural understanding?

## 2. Literature review

### 2.1. Cross-cultural learning and linguistic barriers

Chinese international students in EMI classrooms commonly confront the challenges of linguistic adaptation and cultural adjustment simultaneously. In possession of formal English proficiency, many still find it challenging to align with the swift lecture tempo, interpret discipline-specific jargon, and comprehend idiomatic expressions [1]. The dearth of identifiable linguistic supports may lead to comprehension challenges, whereas the disparity in classroom standards, exemplified by the expectation for active involvement, dialogue, and self-guided exploration, may significantly differ from past educational practices in China [2, 3].

The scope of these issues surpasses straightforward linguistic comprehension. Cross-cultural comprehension is characterized by the decoding of cultural metaphors, the engagement with relevant background knowledge, and the adherence to contextually fitting interaction norms [4, 5]. The bulk of current scholarly work centers on linguistic skills and second-language acquisition; however, the impact of technology, particularly AI translation, on cross-cultural understanding in EMI environments has received limited scholarly attention [6, 7].

### 2.2. Affordances of AI translation tools in education: the “cues” route

Students' views on AI translation tools are shaped by their varied functionalities. Feedback presentation in interface design, with elements like error highlighting, cultural annotations, and

adaptive prompts, is conducive to increased transparency and user trust [8, 9]. In juxtaposition, tools without contextual cues or explanations may induce users to either blindly accept or entirely reject the outcomes, due to perceived inaccuracies [10, 11].

The way algorithms act also shapes user experience. Meanwhile, “weak AI” systems rely on statistical or rule-based translation approaches; more sophisticated generative AI models (e.g., ChatGPT) display greater comprehension of context and the capability to get near cultural adaptation in translation tasks [12, 13]. Nonetheless, research reveals persistent shortcomings in handling figurative language, pragmatic inference, and culturally embedded references [8].

Past experiences and cognitive shortcuts further modify the interaction. The dynamics of trust establishment are culturally nuanced, with collectivist and high-context cultures placing a premium on practical utility and contextual sensitivity over algorithmic transparency, whereas low-context cultures emphasize explicitness and consistency [3, 14]. The discrepancies highlight the imperative for culturally sensitive design in AI translation systems to facilitate usability and deployment among varied learner demographics [15, 16].

### **2.3. Human–AI interaction and the learning process: the “action” route**

Significant educational outcomes are contingent upon the nature of human-AI interaction, in addition to affordances. Learners refine translations, clarify ambiguities, and compare system outputs via iterative prompting and multi-round feedback loops [8, 17]. These exercises enhance engagement and foster unintentional language learning.

The extent of user control over AI translation, termed agency, varies among individuals and across different cultural groups. Initial acceptance of AI outputs by learners from high-context cultures is often due to deference to authority. Nonetheless, targeted training can promote autonomy, encouraging students to modify, verify, and contextualize their outputs [1, 6].

From the vantage point of social exchange, learners juxtapose the benefits of real-time comprehension and worry alleviation with the potential costs of overreliance and potential long-term language regression [2, 18]. Cultural perspectives on tool dependency further influence the cost-benefit assessment, with some learners perceiving AI support as a legitimate collaborative tool, whereas others consider it detrimental to authentic language proficiency.

The synergy between human cultural knowledge and AI's computational efficiency, as the concluding point, is identified as an ideal interactional model. The AI expedites the interpretation of surface meanings, while human users refine and double-check cultural nuances [5, 13]. Rarely does current research delve into the perpetuation of collaborative practices within cross-cultural educational settings.

### **2.4. Mechanisms of cross-cultural understanding and the research gap in AI mediation**

Cross-cultural understanding in EMI contexts is rooted in both linguistic decoding and socio-cultural reasoning. Theories such as Hofstede's cultural dimensions and cultural adaptation theory highlight the roles of background knowledge construction, contextual inference, and interpretation of non-verbal and pragmatic cues [3, 5]. Effective translation must therefore convey not only semantic content but also contextual framing, speaker intent, and culturally embedded meaning [4, 7].

While AI translation tools have advanced in speed and surface accuracy, studies show they still struggle with cultural information transmission, metaphor interpretation, and context reconstruction [9, 12]. Generative models may simulate conversational tone and cultural awareness, but these

capabilities are inconsistent and often reliant on training data that may not capture the full diversity of communicative norms [15, 16].

The literature reveals a clear research gap: there is a paucity of systematic studies situated at the intersection of (a) EMI classroom contexts, (b) Chinese international students, and (c) AI translation tools. Existing works tend to isolate the study of tool affordances (the “cues” route) or learning behaviors (the “action” route) without integrating them within a coherent theoretical framework that also addresses cross-cultural learning outcomes [11, 17]. This fragmentation limits understanding of how AI-assisted translation can be optimally designed and deployed to foster both linguistic proficiency and intercultural competence.

## **2.5. Summary and transition to the present study**

Collectively, prior research offers valuable insights into the capabilities and limitations of AI translation tools, user interaction patterns, and the complex demands of cross-cultural understanding. However, these strands remain largely siloed. Few studies have systematically integrated the analysis of technological affordances, human–AI interaction behaviours, and intercultural learning processes within a unified theoretical model such as HAI-TIME [11].

The present study responds to this gap by investigating how Chinese international students engage with AI translation tools in EMI classrooms, focusing on how cues and actions interact to shape both immediate learning experiences and the development of cross-cultural understanding. By bridging these domains, the research aims to advance theoretical and practical knowledge on the role of AI translation in mediating intercultural learning.

## **3. Methodology**

### **3.1. Participant**

A total of twenty-three Chinese international students (9 males, 14 females), aged between 18 and 25 years ( $M = 22.48$ ,  $SD = 1.95$ ), participated in this study. All participants were enrolled in English-medium instruction (EMI) programs at universities located in the United States, the United Kingdom, Hong Kong SAR, or Australia. Participants represented diverse educational levels (undergraduate and graduate) and possessed varied academic experiences within their respective institutions. Crucially, all participants reported prior and current experience utilizing AI-powered translation tools in their academic coursework.

### **3.2. Interview procedure**

The primary channel for recruiting participants is through social media, and Red Note is the major social media platform. Eligibility and student status were verified by requesting participants to provide documentation (e.g., student ID card, enrollment confirmation, or graduation certificate). Due to the geographical dispersion of participants and researchers, all interviews were conducted remotely via online meeting or phone call and audio-recorded with participants' permission. The average time of the interviews was 45 minutes.

### **3.3. Interview instrument**

A semi-structured interview protocol was employed to elicit detailed accounts of participants' experiences using AI translation tools within cross-cultural academic classroom settings. The

protocol guided participants to reflect on their interactions and perceptions with AI translation during learning activities. The interview schedule comprised four distinct sections: (1) background information, including nickname, age, country, university, and the software of AI translation they use during the class; (2) cue route, the understanding of AI translation, and prior experience of using it; (3) action route, focus on interaction, agency, social exchange, and mutual augmentation; (4) the suggestion or improvement for AI translation.

#### 4. Data analysis

All interview recordings were transcribed verbatim using the “iFLYREC” transcription service, followed by manual verification to ensure accuracy. This process resulted in a total of 253 pages of transcripts for analysis. Data analysis was conducted using thematic analysis [19]. The transcripts were first read repeatedly to ensure familiarity with the content. A dual coding framework was then established, incorporating both the HAI-TIME theory and a cross-cultural understanding dimension.

The open coding phase entailed manual coding via Excel. Examples of the initial codes contained 'high-frequency use of AI translation', 'evident platform-specific tendencies', and 'facilitation of cultural understanding'. Two researchers coded each transcript separately, and the resultant data were merged to ascertain the reliability of the coding. The open codes were then sorted under pertinent themes within the coding framework. For instance, 'repeated input adjustment', 'cross-platform comparison and switching', and 'expression strategy modification' were all classified under the theme 'Interaction'.

In the final analysis, the coded data were examined to ascertain potential correlations between theoretical themes and to investigate the implications of AI translation on international students' cross-cultural comprehension. Illustrative excerpts for each theme are presented in the results section under pseudonyms to protect participant confidentiality.

#### 5. Results

Employing the HAI-TIME theoretical framework, findings were segmented into 'cue-route' and 'action-route' themes. Participants in the 23 interviews pointed to the multifunctional benefits of AI translation tools, particularly their accuracy, quick feedback, and cross-platform availability. When describing these affordances, participants distinguished between what they called weak AI—tools such as DeepL, Google Translate, and Youdao, which offer single-function translation often powered by smaller language models—and Artificial General Intelligence (AGI) systems such as ChatGPT, which integrate translation with conversational and other task-oriented functions [16]. This distinction reflected not only technical awareness but also a nuanced understanding of the roles these tools play in academic and cross-cultural learning contexts.

Patterns of use varied substantially. Some participants (21 of 23) described themselves as high-frequency users, incorporating AI translation into nearly every stage of classroom engagement and independent study, both for comprehension and for producing academic output. Others (2 of 23) reported a more selective, low-frequency use, engaging AI translation only when encountering unfamiliar vocabulary or domain-specific discourse.

Applications spanned a range of educational contexts. The most frequently reported setting was after-class work, including reading, drafting, and revising assignments. Real-time translation during lectures was also common, particularly for decoding dense or fast-paced content, although the immediacy of this context often restricted opportunities for verification. Group discussions

constituted another major setting, where AI translation served as a collaborative resource to support shared understanding and task completion.

## 5.1. Cues route

### 5.1.1. Interface manifestation

Participants identified distinct differences in how interfaces presented translation results and reliability cues. The absence of explicit error notifications in some platforms was seen as a potential risk, as it could allow inaccuracies to pass unnoticed.

The translation software did not flag any errors, and there were no prompts about accuracy.

[kw, 24, USA]

In contrast, certain tools provided prompts highlighting key content or indicating ambiguous segments, prompting users to revisit and verify outputs.

Most tools do not, but I think ChatGPT does. I remember once there was some sensitive content and ChatGPT displayed a small line of text reminding me that a second check might be needed to see whether the translation here was correct.

[Liu, 21, UK]

Many participants also noted that cultural cues were often missing, limiting the tool's ability to explain idiomatic or context-bound expressions—an absence that could be especially consequential in cross-cultural academic environments.

### 5.1.2. Algorithm attributes

When discussing algorithmic logic, most participants admitted to limited understanding of how translation models functioned. Weak AI platforms were often described as performing literal, word-by-word translation with insufficient contextual awareness, leading to awkward renderings of idioms and slang.

There is an English idiom 'it's raining cats and dogs,' which actually means it is pouring with rain. If you translate it literally, the output will very likely be that cats and dogs are falling from the sky, which is a literal translation.

[Kevin, 19, HongKong]

Participants also observed that different platforms produced markedly different outputs, with some showing a preference for particular lexical or syntactic styles. Such “platform tendencies” influenced tool choice, leading users to favor those offering more accurate or stylistically preferable results.

Doubao and Kimi are less accurate and feel rather clumsy, so I will gradually stop using them. I prefer tools that give me a better experience such as GPT and DeepSeek.

[Xin, 22, UK]

### 5.1.3. Prior experience

Past experiences shaped current usage habits. Negative incidents—such as mistranslations that directly affected graded work—prompted greater vigilance and more systematic verification.

After experiencing mistranslations that led to a high error rate in the assignment I submitted, I now rethink things after reading the AI output and only then complete my assignment.

[Emily, 18, Australia]



These experiences also encouraged adaptive strategies such as rephrasing inputs, experimenting with prompts, and cross-checking across platforms to improve results.

#### 5.1.4. Cognitive heuristics

Participants generally expressed a baseline trust in AI translation, framing it as relatively objective due to its algorithmic nature. However, they also agreed that cultural adaptation remained a weak point and could result in misunderstandings.

For AI translation programs, because they are based on AI, many settings do not allow them to make very radical or unreasonable statements, so they are relatively objective compared with others. However, they lack cultural understanding, and there are indeed things they cannot reach.

[Krystal, 19, USA]

### 5.2. Action route

#### 5.2.1. Interaction

Participants frequently engaged in multi-turn exchanges with advanced AI models such as ChatGPT. They contrasted this with weak AI translation tools, which were generally limited to a simple “input–output” process with minimal opportunity for follow-up clarification. By contrast, AGI systems enabled sustained, conversational interaction, allowing users to refine translations through iterative prompts, request explanations for ambiguous terms, and explore alternative phrasings. This higher level of interactivity was seen as particularly valuable for improving contextual fit and addressing cultural nuances, turning the translation process into an adaptive, collaborative exercise rather than a static transaction.

I will ‘train’ the AI. I tell it your translation is incorrect, explain what it should look like, and then ask it to try again. Through this kind of dialogue I improve its accuracy.

[Xin, 22, UK]

It was also common to cross-check translations across multiple platforms, selecting the most reliable or context-appropriate output.

I take both the original text and the translation to another AI and ask whether there are errors and how to revise them.

[Funa, 23, UK]

Some participants altered their own writing strategies—such as composing Chinese text with an “English-thinking” structure—to produce translations that read more naturally in English.

When I later write in Chinese, I sometimes write with an English way of thinking so that the translation will read more like an English article.

[Xin, 22, UK]

#### 5.2.2. Agency

Half participants (12 of 23) reported limited control over AI translation outputs, citing insufficient customization options. Some mitigated this by adjusting settings or incorporating manual review, but most acknowledged a passive acceptance of the system’s results.

My control over AI translation is basically limited to the instructions I type in the text box, which the system then uses to try to meet my expectations.

[Krystal, 19, USA]

Others (11 of 23) reported a strong sense of control, especially when translating from Chinese to English.

I think I can control it. I think there is more control when translating from Chinese to English.

[kw,24, USA]

Errors occasionally propagate into consequential settings, underscoring the importance of vigilance.

We did a crisis simulation on the spot, and the time was very tight. My AI translated an epidemic-related term incorrectly as the English for a pandemic, and I sent it without checking. Some classmates were playing reporters, and they went wild, asking whether this was a pandemic or just an epidemic, which caused a disturbance in the class.

[Mu, 24, Sweden]

Real-time classroom translation further constrained control due to the pace of interaction, leading most users to accept outputs without modification.

### 5.2.3. Social exchange

Participants evaluated AI translation through a cost–benefit lens. Costs included time spent learning prompting strategies, subscription fees, and the cognitive load of verification.

You may need to keep tweaking it, repeatedly entering instructions to get the answer you ultimately want.

[Zhang, 23, UK]

The obvious one is money. For example, with ChatGPT, you need to pay for a subscription.

[You, 23, UK]

The most widely recognized benefits were increased efficiency in understanding course content and improved accuracy in grasping academic terminology.

It can definitely help us save time to a certain extent.

[Ian, 19, USA]

It can quickly give you some ideas and an outline. In a non-native state, when you are searching for the right words, you may be unable to fully express what you want to say.

[Krystal, 19, USA]

Some expressed concern that long-term reliance could erode independent thinking or language skills.

The cost is that I lose my own ability to think.

[Emily, 18, Australia]

Real-time interpersonal exchanges with instructors were a frequent boundary where participants avoided visible reliance because of social awkwardness.

I generally do not use it. It is impossible for me to pause halfway through speaking and say please wait while I translate this. That would be very strange.

[kw,24,USA]

It feels like outsourcing my voice to a machine. I try not to overuse it.

[Liu, 21, UK]

### 5.2.4. Mutual augmentation

Findings indicate a reciprocal arrangement in which users actively compensate for model limits while models scaffold users' linguistic resources. Users enhanced outputs through targeted context provision, cross-tool comparison, and human review.



Because it is AI, the data are too general and cannot determine a specific scope. I provide additional background to the AI and ask it to follow my needs completely when revising.

[Zhang, 23, UK]

Models, in turn, supplied lexical variety, genre-appropriate phrasing, and cultural hints that lowered barriers to participation and confidence.

For some everyday expressions and slang that I do not understand, I ask it to translate them so that I can better grasp what people actually mean, which helps me cross cultural barriers.

[Ian, 19, USA]

If the teacher calls on me, having AI generate a more polished answer will certainly make me more confident.

[Yu, 23, UK]

Participants nevertheless warned about possible declines in reading capacity with overreliance.

If you rely on translation software in the long term, there is not much difference from being in China. The only difference may be an improvement in speaking because the AI cannot help you speak, and you have to do it yourself.

[kw, 24, USA]

My reading ability may decline... At times, I need to be particularly vigilant to avoid becoming overly reliant on this approach.

[Loca, 25, UK]

### 5.3. Suggestions for improvement

The interviews pinpointed two primary domains requiring refinement. The initial matter involved transparency as a focal point. Enhanced trust in AI translation systems is contingent upon transparency in translation origins, dataset and algorithm disclosure, and the clarification of translation rationale. Users' ability to assess output quality and make informed decisions on reliability was contingent upon transparency. Users' ability to assess output quality and make intelligent decisions on reliability was contingent upon transparency.

The second domain encompassed the fusion of cultural information. Participants pointed out the necessity of cultural context tools in cross-cultural translation, emphasizing the inclusion of idiomatic annotations, specialized term explanations, and usage scenario guidance. The integration of these features was regarded as a strategy to amplify the interpretability and utility of translations, especially in educational contexts where cultural subtleties are essential for comprehension. The incorporation of these features was seen as a method to improve the interpretability and utility of translations, especially in educational environments where cultural nuances are essential for understanding.

## 6. Discussion

Semi-structured interviews were the method chosen by the study to investigate the user experience of AI translation tools in cross-cultural educational settings. An intensive study was undertaken of the interactional pattern linking the cue and action paths. The intricate connections between themes within the action path are delineated, thereby exposing the complex nature of human-AI collaboration. The analysis, constructed upon the HAI-TIME framework [11], verified its explanatory attributes and expanded its application domain.

Before human-AI interaction, participants exhibited clear preferences regarding AI tools, distinguishing between weak AI tools (possessing only a single translation function) and AGI

(possessing conversational interaction capabilities) [16] with a marked preference for the latter. AGI was favored due to its anthropomorphic, flexible, and interactive mode of engagement. Notably, users universally demanded algorithmic transparency, emphasizing the need to disclose data sources (e.g., "BBC corpus") and cultural stance labels (e.g., "US-perspective translation"). This precisely demonstrates the characteristic invisibility of AI algorithms [11].

The Action route is moderated by the Cues route. Empirical evidence indicates that manifestations of the Action route—particularly levels of interaction and agency—are significantly influenced by the Cues route. For instance, interface manifestations that provide error feedback or cultural cues encourage greater user interaction and enhance perceived agency. Conversely, the absence of such interface cues often leads to passive acceptance of translation outcomes and reduced interaction. Similarly, algorithm attributes and prior experience shape user trust (cognitive heuristics). This trust or skepticism directly determines the extent of effort invested in iterative prompting or cross-checking (interaction), and the willingness to refine inputs to exercise control over outputs (agency). Complex interconnections define the relationship between agency and interaction. Users' awareness of their ability to shape AI outputs fosters increased proactivity in crafting queries, refining inputs iteratively, and seeking alternative expressions, thereby augmenting the frequency and quality of interactions. Participants iteratively corrected ChatGPT's translations until the outputs met their predefined standards. Consequently, the iterative process strengthens users' sense of agency, as they discern that altering inputs or rephrasing prompts facilitates the AI's generation of outputs more in line with their goals. Feedback cultivates their perceived efficacy in directing AI behaviors.

The AI-human interaction process is marked by participants' tendency to simultaneously employ multiple AI tools. They actively engaged in measures to cross-verify translation results (e.g., confirming DeepL's translations via ChatGPT or enhancing reliability with manual verification). It is apparent that users did not completely abdicate control; the AI functioned as a partial agent for particular tasks. The extent of AI autonomy was contingent upon contextual factors and the capabilities of individual participants. The extent of AI autonomy was contingent upon the context and the capabilities of individual participants. In time-sensitive scenarios (e.g., real-time classrooms), AI dominance increased. Conversely, users regained control in autonomous tasks (e.g., post-class reading). Language proficiency also emerged as a critical factor: high-proficiency users (e.g., long-term overseas students) demonstrated lower dependency on AI. These users actively reconstructed agency through strategies like multi-tool cross-verification. Low-proficiency users, however, were more prone to rely on AI agency, often foregoing manual verification of AI translations. They perceived AI capabilities as vastly superior to their own, believing their verification would not alter the AI's output, leading to interaction patterns devoid of verification steps.

The findings confirm the applicability of Social Exchange Theory [20, 21]. As predicted by the theory, social interaction constitutes an exchange behavior where users strive to maximize benefits while minimizing costs. In this context, beyond the most obvious monetary cost, user efforts within the interface (searching, configuring searches, and manual verification) are all perceived as costs, while the convenience and personalized content provided by the AI constitute benefits. Users continuously weigh these costs against benefits to achieve a net gain. Within the translation context of cross-cultural classrooms, the trade-off between trust and risk represents a unique benefit-cost dynamic: while trusting AI for swift results, users also bear the risk of potential translation errors. Therefore, the act of manually verifying AI results is itself a process of minimizing costs (risk) to enhance benefits (reliable understanding). Moreover, this exchange process exhibited dynamic

characteristics. Driven by positive net benefits, users continued tool usage when benefits outweighed costs. However, when certain costs, such as interpersonal communication costs, increased, users adjusted their behavior or even abandoned AI use. This explains why interviewees discontinued AI usage in classroom situations demanding face-to-face communication. Agency modulates users' cost-benefit calculus within the Social Exchange framework. When users perceive stronger control, they demonstrate greater willingness to invest time and effort (costs) to secure high-quality translation outputs (benefits). Conversely, diminished agency correlates with increased acceptance of suboptimal results.

While human-AI synergy yielded positive effects, such as reduced language anxiety [18], leading to increased classroom participation, the study also revealed inherent contradictions. Long-term dependence potentially weakens language internalization capabilities, and obscured cultural stances create risks of misinterpretation. These findings prompt us to re-examine HAI-TIME through the lens of the double-edged sword framework. The positive benefits (removing communication barriers) and hidden costs (skill atrophy) form a dialectical unity; the equilibrium point of which depends on user capabilities and contextual demands. Frequent interaction often serves as a prerequisite for achieving human-AI complementarity; the formation of this complementary relationship in turn enhances the depth and quality of interaction. Interaction and mutual augmentation are thus mutually reinforcing. Mutual augmentation emerges as a synthesis of interaction, agency, and social exchange dynamics. Complementary relationships are more readily established only when sustained interaction, substantial agency, and favorable cost-benefit calculus coexist.

The outcomes derived from the Action route—encompassing interaction, agency, social exchange, and mutual augmentation (e.g., obtaining refined translations through multi-turn interactions and manual optimization)—subsequently reshape users' prior experience and cognitive heuristics. Given that users' perception of the Cues route directly influences their Action route behaviors, this constitutes a bidirectional cycle.

## **7. Implications**

### **7.1. Theoretical implications**

This study confirms the applicability of the HAI-TIME framework in cross-cultural, English-taught classrooms and extends its perspective to educational contexts. It enriches the understanding of “mutual augmentation” and clarifies relationships between themes, particularly how cue-route factors shape action-route processes, how different themes are interrelated and operate together in shaping human–AI translation processes.

### **7.2. Practical implications**

The findings offer guidance for integrating AI translation tools effectively in cross-cultural education, helping educators support students' learning while fostering independent language and cultural competencies.

The implications for AI translation tool design point to several potential improvements. One promising direction is multi-AI comparison visualization, which would integrate outputs from different systems such as DeepL, ChatGPT, and Doubao into side-by-side displays that highlight differences, thereby allowing users to evaluate and select the most accurate or contextually appropriate translation. Another important enhancement is cultural transparency, where the system

could automatically annotate sensitive or culture-specific terms with references to their data sources—for example, labeling a phrase as “Based on the BBC corpus.” Together, these features could not only improve user trust but also strengthen the cultural adaptability and interpretability of AI translation tools.

## 8. Limitations and future directions

This study has two main limitations. First, the sample size was small and limited to students in English-taught classrooms in the UK, Australia, and the United States, excluding other language contexts. This restricts the representativeness and generalizability of the findings. Second, the study relied solely on qualitative interviews, without behavioral or quantitative data to validate and triangulate the results.

Future studies could expand the sample to include diverse linguistic backgrounds and academic disciplines, allowing comparisons across contexts. Experimental designs could be used to examine the causal effects of AI translation tools on learning behaviors under controlled conditions. Additionally, future research may explore the relationship between language proficiency (e.g., IELTS or TOEFL scores) and reliance on AI translation tools, and further investigate how such usage influences students’ cross-cultural understanding in multilingual and multicultural classroom settings.

## 9. Conclusion

This study demonstrates the applicability of the HAI-TIME framework in cross-cultural, English-taught classrooms and extends the theory by revealing and elaborating on the interconnections among its themes within this educational context. The findings deepen our understanding of human–AI collaboration in cross-cultural learning, while also cautioning against the risks of overreliance on AI translation tools. By offering insights into how human and AI strengths can be balanced and integrated, this research contributes to the development of more effective human–AI symbiotic ecosystems for learning and cultural exchange.

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## Appendix

### Outline for In-depth Interview

## I. Background Information – Icebreaker Session

1. Do you utilize AI translation in cross-cultural classroom settings?
2. Which AI translation tools do you commonly use, and what is your frequency of usage?
3. In what classroom scenarios is AI translation primarily employed? (e.g., real-time instruction, group discussions, post-class assignments)

## II. Cue Route – Perception and Heuristic Cognition of AI Translation

### (A) Interface Manifestation

1. Please describe the interface characteristics of the AI translation tool you use (e.g., error notification styles, cultural term annotation placement).
2. Which design elements in the interface alert you to potential issues in the translation results? (e.g., red squiggly lines, low confidence icons)
3. Does the interface provide prompts when translations involve culturally or politically sensitive content (e.g., religious terminology)? Please provide examples.

### (B) Algorithm Attributes

1. Do you understand the operational logic of the tool? (e.g., Do you believe it prioritizes literal or free translation?)
2. Describe the patterns you have observed in AI translation's handling of cultural differences (e.g., strategies for translating Chinese honorifics).
3. Have you noticed systematic differences in translation results across platforms (e.g., Google Translate vs. DeepL)?

### (C) Prior Experience

1. How have past positive or negative experiences with AI translation influenced your current usage practices?

Example: After a cultural mistranslation, did you incorporate additional manual verification steps?

2. Have these experiences altered your default level of trust in translation results? Please explain with specific scenarios.

3. From where have you learned methods to optimize AI translation? (e.g., peer recommendations, trial and error)

### (D) Cognitive Heuristics

1. What is your initial judgment of translation results when you see labels such as "AI-generated"?
2. Have you ever perceived AI translation as more objective, or conversely, as lacking cultural understanding? Please describe specific situations.
3. Has AI translation ever led to heuristic errors in the classroom? (e.g., blind acceptance of translations resulting in cultural misunderstandings)

## III. Action Route – Human-Machine Collaboration and Agency

### (A) Interaction

1. Describe your interaction process with the AI translation tool (e.g., inputting content, revising results, adjusting settings).
2. How do you interact with the tool when translation results contain cultural ambiguities?  
Follow-up: Do you attempt multiple inputs, switch language modes, etc.?
3. Are there instances of collaborative AI translation usage in the classroom? (e.g., teachers and students or student groups jointly interpreting output)

### (B) Agency

1. How do you perceive your control over AI translation?



Example: Can you override its translation results? Do you feel compelled to accept the output?

2. Provide an example of how you proactively adjusted tool settings or usage strategies to achieve classroom objectives.

3. Has AI translation ever unexpectedly influenced your classroom decisions? (e.g., altering discussion directions due to translation errors)

#### (C) Social Exchange

1. What are the primary benefits (e.g., time-saving, reducing language barriers) and costs (e.g., cognitive load, error correction time) of using AI translation?

2. Do you consider these benefits and costs to be balanced? Please describe specific scenarios to support your view.

3. Does the tool impact your collaboration with other students or teacher-student interactions in classroom participation?

#### (D) Mutual Augmentation

1. How does AI translation enhance your capabilities? (e.g., speed in processing multilingual materials)

2. How do you compensate for the limitations of AI? (e.g., supplementing cultural context, correcting mechanical literal translations)

3. Share an experience where human-machine collaboration enhanced cross-cultural understanding.

#### IV. Reflection and Improvement

1. Transparency Needs: What attributes of explanation or disclosure do you expect from AI tools? (e.g., how AI handles data related to cultural biases)

2. If designing a new feature to improve cultural translation reliability, what would you prioritize? Interface prompts, attribute explanations, or other aspects?